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An Enumeration of the Plants Collected by Dr. H. H. Rusby in South America, 1885-1886.—XXIII.

(Continued from Vol. XIX., page 374.)

VACCINIACEÆ.

Psammisia leucostoma, Benth.; Meisn. in Mart. Fl. Bras. vii. 127. Mapiri, 2,500 ft. (2038). The same as Spruce, No. 2465 from Brazil.

Psammisia pauciflora, Griseb. in Pl. Lechl. Exc. 2386. Mapiri, 5,000 ft. (2037). The same as Lechler, 2386 from Peru. This may be a *Macleania* as indicated by Bentham and Hooker, Gen. Pl. ii. 567.

EURYGANIA ELLIPTICA (R. & P.) (*Thibaudia elliptica*, R. & P. Fl. Per. iv. t. 384, f. B). Mapiri, 2,500 ft. (2219); Yungas, 4,000 ft. (2034).

CERATOSTEMMA HOOKERI, Britton. (*Thibaudia elliptica*, Hook. Icon. Pl. t. 108, not R. & P.). Mapiri, 10,000 ft. (2036).

CERATOSTEMMA MANDONI, n. sp. Sect. Euceratostemma. Ramis glabris, striatis; foliis breviter petiolatis, integris, ovatis vel ovato-oblongis, approximatis, concoloribus, supra glabris, subter parce nigro-punctatis, utriusque obtusis, 1-1.5 cm. longis, 5-8 mm. latis, 5-venosi ; pedunculis, calycibusque tomentosis; floribus terminalibus, solitariis geminibusve, 3 cm. longis; calyx 5-fidus, lobi lanceolati, acuti; corolla extus puberulenta, cylindracea, apice 5-fida, calyce 4-5-plo longiora.

Mapiri, 10,000 ft. (2632). Same as Mandon's 748, and probably the same as Lechler's 2693 and 2585 from Gatchapota, Peru, Herb. Kew.

CERATOSTEMMA SERRATA, n. sp. Sect. Siphonandra. Ramulis rugosulis, glabris; foliis breviter petiolatis, ovato-oblongis, utrinque pallidis, subter parce nigro-punctatis, apice acutis, basi rotundatis, margine remote denticulatis, 5-8 cm. longis, 3-4 cm. latis; floribus axillaribus, umbellatis, 3-4 cm. longis; calycibus oblongo-campanulatis, breviter 5-dentatis; corollis glabris, cylindraceis, calyce 2-3-plo longioribus, apice 5-dentatis. Unduavi, 8,000 ft. (2035).

CAVENDISHIA PUBESCENS (H. B. K.) (*Thibaudia pubescens*, H. B. K. Nov. Gen. iii. 273). Yungas, 6,000 ft. (2033).

Cavendishia, sp. Mapiri, 5,000 ft. (2403).

Vaccinium empetrifolium, H. B. K. Nov. Gen. iii. 263, t. 248 ? Unduavi, 10,000 ft. (2022).

Vaccinium floribundum, H. B. K., l. c. 266, t. 251. Mapiri, 10,000 ft. (2028). The same as Mandon's 551.

Vaccinium didynanthum, Dun. in D. C. Prodr. vii. 575. Mapiri, 10,000 ft. (2026).

Vaccinium epacridifolium, Benth. Pl. Hartw. 221. Mapiri, 10,000 ft. (2027).

Vaccinium polystachyum, Benth, l. c. 140. Mapiri, 10,000 ft. (2024).

Vaccinium pernettioides, Griseb. in Lechler Pl. Excs. 2113a. Yungas, 6,000 ft. (2029). The same as Lechler's 2113a.

Vaccinium, sp. Ingenio del Oro (2021).

Sophoclesia, sp. Mapiri, 5,000 ft. (2696).

Rusbya taxifolia, Britton, Bull. Torr. Bot. Club, xx. 68. Yungas, 4,000 ft. (2692).

ERICACEÆ.

Pernettya Pentlandii, D. C. Prodr. vii. 587. Sorata, 13,000 ft. (2017) Yungas, 6,000 ft. (2018.)

Pernettya Pentlandii, D. C. var. *parvifolia* (Benth.) Wedd. Chlor. And. ii. 170. Unduavi, 8,000 ft. (2023).

Gaultheria anastomosans (L. f.) H. B. K. Nov. Gen. iii. 285. Yungas, 6,000 ft. (2025; 2095).

Gaultheria cordifolia, H. B. K. Nov. Gen. iii. 285, t. 261. Yungas, 6,000 ft. (2016).

Gaultheria brachybotrys, D. C. Prodr, vii. 595. Sorata, 13,000 ft. (2014).

Gaultheria rufescens, D. C. Prodr. vii. 595. Unduavi, 8,000 ft. (2013); 10,000 ft. (2011). The same as Mandon's 557.

Gaultheria reticulata, H. B. K. Nov. Gen. iii. 284. Ingenio del Oro, 10,000 ft. (2030).

Gaultheria glabra, D. C. Prodr. vii. 596. Yungas, 6,000 ft. (2015).

Gaultheria tomentosa, H. B. K. Nov. Gen. iii. 287, t. 262. Unduavi, 8,000 ft. (2032). The same as Mandon's 559.

Gaultheria Pinchinchensis, Benth. Pl. Hartw. 225. Yungas, 6,000 ft. (2012).

Gaultheria conferta, Benth. Pl. Hartw. 219. Unduavi, 10,000 ft. (2020).

Gaultheria vaccinioides, Griseb. Pl. Lechler Excs. 1900. Unduavi, 10,000 ft. (2019); Ingenio del Oro, 10,000 ft. (2031).

Befaria glauca, H. & B. Pl. Æquin. ii. 118, t. 177. Mapiri, 5,000 ft. (2010); Yungas, 6,000 ft. (2123).

Clethra fimbriata, H. B. K. Nov. Gen. iii. 290, t. 264. Unduavi, 12,000 ft. (2073). The same as Mandon's 562.

Clethra Brasiliensis, Cham. Linnæa, viii. 510. Yungas, 6,000 ft. (2091).

PLUMBAGINEÆ.

Plumbago scandens, L. Sp. Pl. Ed. 2, 215. Tacna, Chili (1158); Yungas, 6,000 ft. (1917 and 1073).

MYRSINEÆ.

Myrsine dependens (R. & P.) Spreng. Syst. i. 664. (*M. ciliata*, H. B. K.) Unduavi, 10,000 ft. (2491.)

Myrsine erythroxyloides, Benth. Voy. Sulph. 123. Guanai, 2,000 ft. (867).

Myrsine latifolia (R. & P.) Spreng. Syst. i. 664. Yungas, 4,000 ft. (868).

Myrsine Gardneriana, A. D. C. Ann. Sci. Nat. (II.) xvi. 86. Yungas, 4,000 ft. (866 and 869). The same as Spruce's No. 4251.

GEISSANTHUS BOLIVIANA, n. sp. Arbor glabra. Foliis oblanceolatis, coriaceis, integris, multinervis, subtus dilute viridis, apice obtusis, base cuneatis, 15-20 cm. longis, 5-8 cm. latis; petiolis crassis, 2 cm. longis; floribus 2-3 mm. latis, dense paniculatis; paniculis 10-15 cm. longis; calycibus campanulatis, punctatis, 5-lobatis, tubo lobis æqualibus; corollis calyce duplo longioribus.

Mapiri, 5,000 ft. (562). Related to Spruce's No. 5176, Herb. Kew.

Cybianthus, sp. Mapiri, 5,000 ft. (2346). Collected only in fruit.

Cybrianthus, sp. Guanai, 2,000 ft. (1218). Collected only in fruit.

I did not match either of these at Kew. In all probability they are undescribed species.

Ardisia acuminata, Willd. Sp. Pl. i. 1062. Junction of the Rivers Beni and Madre de Dios (2490).

Clavija spathulata, R. & P. Syst. Fl. Per. i. 285 (?). Junction of Rivers Beni and Madre de Dios (2650).

Clavija lancifolia, Desf. Nouv. Ann. Mus. Hist. Nat. i. 402, t. 14. Guanai, 2,000 ft. (1219).

SAPOTACEÆ.

Mimusops Surinamensis, Miq. in Mart. Fl. Bras. vii. 43. Junction of the Rivers Beni and Madre de Dios (729).

Lucuma procera, Mart.; A. D. C. Prodr. viii. 170. Falls of the Madeira, Brazil (2618).

Sideroxylon, sp. Junction of the Rivers Beni and Madre de Dios (2703).

STYRACEÆ.

Styrax ovatum (R. & P.) A. D. C. Prodr. viii. 267. Yungas, 6,000 ft. (838).

Symplocos Matthewsii, A. D. C. Prodr. viii. 250. Mapiri, 5,000 ft. (2686).

Symplocos, sp. Mapiri, 2,500 ft. (2685).

OLEACEÆ.

Jasminum grandiflorum, L. Sp. Pl. Ed. 2, 9. Yungas, 6,000 ft. (1244). Cultivated and escaped.

The Development of the Sporocarp of Pilularia Americana, A. Br.

By Douglas Houghton Campbell.

(Plate CXLVI.)

Pilularia Americana is by no means uncommon in California, and is said to be especially abundant in the Sacramento Valley. Last spring a quantity of fresh specimens, collected near Suisun, were sent me by Mrs. Brandegee, and as they bore numerous sporocarps, in all stages of develoyment, it seemed a good opportunity to attempt to clear up some obscure points in the early development of the sporocarps of the Marsiliaceæ.

Without microtome sections, it is quite impossible to study the earliest stages satisfactorily on account of their small size, and because they are completely buried in a mass of hairs that cover the growing point of the stem, and all of the younger parts in its vicinity. Those hairs cannot be removed from the young sporocarp and interfere very seriously with a clear view of it.

Our knowledge of the development of the sporocarp of *Pilularia* is based mainly upon the work of Sachs,* Goebel,† and Jurányi,‡ and that of *Marsilia* upon Russow's investigations.§ The origin of the sporocarp itself, however, and the formation of the cavities in which the sporangia are borne, was not clearly understood.

By imbedding in paraffine in the usual way and sectioning with a microtome, no trouble was experienced in getting a complete series of preparations that showed all the details, and the results of a study of these is here given. In preparing the specimens for sectioning, the growing tips of the fruiting plants were treated for two or three hours with a 1 per cent. aqueous solution of chromic acid, washed, stained *in toto* with alum cochineal, and after sectioning, stained on the slide with alcoholic Bismarck-brown; my usual method of preparing sections of young tissues.

* Sachs, Text-Book of Botany, 2 ed., pp. 455–460.

† Goebel, "Outlines," p. 240, foot note.

‡ Jurányi. The original paper in Hungarian. Reported in Just's Jahresbericht, Jahrgang 1879, p. 416.

§ Russow. Histologie und Entwickelungsgeschichte der Sporenfrucht von Marilia. Dorpat, 1871.

The creeping stem of *Pilularia* grows from a single tetrahedral apical cell, from which three series of segments are cut off, as in most ferns. Two of these series give rise to the two rows of leaves, and from the third, roots only are formed. The stem branches freely, the branches arising close behind its apex.

Leaves of two kinds are formed, fertile and sterile; the former differ from the latter simply in bearing a sporocarp. The foliar nature of the sporocarp has been inferred from analogy with the ferns, and also from a study of the position of the older sporocarps but the way in which it originates from the leaf was not known. Juranyi * states that in *P. globulifera*, the formation of the fruit begins, only after the leaf has reached a considerable size. My own observations on *P. Americana* do not confirm this. On the contrary, the yonng fruit begins to develop almost as soon as the leaf can be recognized, and while it is still close to the apex of the stem, long before it is large enough to be seen with the naked eye.

The young leaf, like the stem, grows from a tetrahedral apical cell. Growth at first is stronger upon the outer side, and in consequence, even at a very early stage, the leaf is strongly coiled, as in all the homosporous Leptosporangiates. In the fertile leaves, however, before this curvature has become very pronounced, a protuberance may be noticed upon its inner face, not far above the base. (Fig. 1, M.) This originates from the growth of a single cell (x), which acts as an apical cell in the same way as that of the apex of the body of the leaf. This protuberance is the young sporocarp which at this stage is clearly seen to be simply a segment or branch of the fertile leaf.

The young sporocarp enlarges rapidly after its formation and assumes the form of a blunt cone. Next, on the side turned toward the sterile segment of the leaf which bears it, a slight prominence is noticed (Fig. 2, F.), and about the same time two similar lateral prominences are formed. As in the sterile segment growth is stronger on one side (here the side turned away from the sterile segment), and in consequence the sporocarp bends over toward the sterile segment of the leaf. The apex of the young sporocarp (Fig. 2, F.), together with the three prominences referred to, enclose a slightly depressed area which is top of the young sporo-

* L. c.

carp. The four prominences (including the original apex of the fertile segment), are beyond doubt to be regarded as leaflets, which, however, are never much elevated above the surface of the young fruit, and in this first stage form four slightly elevated ridges.

A little later (Fig. 3), these become more prominent, and a slight depression or pit is formed between the base of each and the cells occupying the top of the young sporocarp. These pits are separated laterally by the coherent margins of the leaflets which extend to the axis of the sporocarp and are continuous with it. The young fruit now enlarges rapidly, and as it does so the depressions deepen owing to the elongation of the leaflets, and also to that of the cells of the axis of the sporocarp, which form a sort of columella running through the center.

The leaflets, or as we will now call them, lobes, are only free at their tips; and as the edges are in contact from the first and extend to the axis, the clefts between them and the axis form four deep cavities that open by as many pores at points opposite the tips of the lobes. These pits correspond to the "canals" described by Russow in the fruit of Marsilia.

Juranyi states that these cavities are caused by a splitting apart of the cells of the inner tissue of the sporocarp, and that the communication with the outside is brought about by the subsequent separation of the cells at the apex of the sporocarp; that is, that the cavities are endogenous in origin. Doubt has been expressed as to the accuracy of these statements, and Goebel states that his observations do not bear them out.

A study of longitudinal sections of the young sporocarp show beyond doubt the strictly external origin of these cavities.

Up to the time that the cavities begin to form, the young fruit is composed of a uniform, small-celled parenchyma, but a little later, however, the primary tissue systems are differentiated, and the separation of the body of the sporocarp from its peduncle becomes evident. About the same time the axial cells in the basal part of the sporocarp extending into the peduncle, elongate and form the beginning of the single fibro-vascular bundle that traverses the peduncle and joins that of the sterile segment of the leaf near its base.

The peduncle grows rapidly and becomes several times longer than the sporocarp itself—(Fig 5). The growth upon the upper side of the latter is stronger than upon the lower side, and in consequnce, it becomes bent over, nearly or quite at right angles to the peduncle. With the enlargement of the sporocarp the cavities within become deeper and wider in a direction parallel to the broad surfaces of the lobes; but the radial growth of these keeps pace with the longitudinal growth, so that the space between the inner surface of the lobe and the columella, is very narrow. The growth is especially active in the inner epidermal cells, which project more or less and form a cushion running vertically along the median line of each lobe. This cushion is the sorus (Fig. 5. 6. 8.), and as its surface cells develop into the sporangia, it nearly fills the cavity in which it lies. A tranverse section at this time shows that the portions separating the cavities are composed of about four layers of cells.

The fibro-vascular bundle which traverses the center of the peduncle divides into four branches at the base of the sporocarp, and one of these goes to each lobe and forms a sort of midrib (Fig. 6.). Later each of these bundles sends off two lateral branches that follow the margins of the lobe. A cross section of a sporocarp at this stage (see Fig. 9), shows these as groups of small cells at nearly equal distances from each other, one at the center of the lobe, the others close to its margin. By this time the epidermal cells of the outside of the sporocarp begin to thicken. This is the first indication of the hard shell found in the ripe fruit.

While these changes are going on in the outer tissues of the sporocarp, the sporangia have begun to develop from the surface cells of the sori. Active growth begins in these cells, which become elevated as papillæ above the surface of the sorus. This is most marked in the basal or older cells, but proceeds rapidly toward the upper end of the sorus. While in a general way we may say that the sporangia arise in acropetal succession, still new ones arise later among the earlier formed ones, without reference to their position; indeed all of the surface cells of the sori may be regarded as potentially, at least, sporangium mother-cells.

There is a good deal of variation in *Pilularia*, as in many ferns, as to the direction of the first division walls in the young sporan-

gium, and it seems to me that too much stress has been laid upon this by some writers.

In the earlier sporangia the first division walls are usually strongly oblique, but even here the first wall may be transverse (see Fig. 7, a.), as usually happens in the Polypodiaceæ. Several oblique walls now arise which meet each other in such a way that the terminal cell has much the form of an ordinary tetrahedral apical cell. Soon, however, a wall is formed parallel to the outer wall of the terminal cell, and thus an inner cell (Fig. 7, c.), the archesporium, is cut off. The archesporium is formed relatively earlier in the first formed sporangia which are almost sessile, while in the later ones, where they are more crowded, the pedicel is much better developed (Fig. 10).

From the archesporium the tapetal cells (t.), are cut off in the usual way, and subsequently these divide by both radial and tangential walls into a large number of cells. For the most part there is but one set of tangential divisions, but sometimes there is a second one in some of the cells, so that at these points the tapetum is three cells thick.

The central cell divides by an oblique wall into two cells and these each divide twice more, and sometimes some or all of the resulting cells may divide again, so that the whole number of the resulting spore mother-cells ranges from eight to sixteen.

When the full number is complete the cells separate owing to the partial disintegration of the division walls, and, at the same time, the walls of the tapetal cells become completely absorbed and their contents form a mass of protoplasm in which the separated spore mother-cells are imbedded. These now increase somewhat in size and become globular as the pressure of the surrounding cells is removed. The sporangium has now increased a good deal in size and the spore mother-cells do not completely fill it.

In fresh sporangia the tapetal cells appear completely disorganized, but when stained sections are examined it is evident enough that the protoplasm and nuclei of the cells persist unchanged, and the further development shows that the protoplasm and nuclei of the tapetum probably play an important part in the further growth of the spores.

The division of each of the spore mother-cells into four shows nothing peculiar. The nucleus divides twice before any division of the protoplasm takes place, and the four daughter-nuclei arrange themselves at equal distances from each other near the periphery of the cell, after which division walls are formed simultaneously between them, and the resulting spores are of the tetrahedral type.

Up to this point the sporangia are all alike, but now a difference is noticed between those in the lower and those in the upper part of the sporocarp. The former develops into macrosporangia, the latter into microsporangia. In the latter all of the young spores come to maturity, but in the former one spore very early begins to grow faster than the others, which finally shrivel up and develop no further. The young macrospore is at first nearly globular, but soon becomes oval, and finally completely fills the sporangium. In its early stages the membrane is thin, but as it grows it becomes very thick. A slight examination shows that the spore is surrounded by a layer of protoplasm, in which are imbedded a great many nuclei. This protoplasm is no doubt that derived from the tapetum, and its position indicates that it, with its included nuclei, is actively concerned in the nourishment of the growing macrospore. This office is probably two-fold; first to provide material or the growth of the spore contents, and secondly to deposit upon the outside of the spore the material for the formation of the peculiar and highly specialized spore coat, characteristic of the Marsiliaceæ. The development of the spore membrane seems to be the same in the microspores, but owing to their smaller size is not so easy to trace out. The wall of the sporangium remains but one cell thick, and shows no traces of the annulus found in all the terrestrial leptosporangiate ferns. This complete disappearance is in allprobability to be traced to a loss of function. In the terrestrial ferns, the opening of the sporangium is brought about by drying up, and the contraction of the annulus by drying is the principal factor in the process. In the Marsiliaceæ, on the contrary, the sporangium only opens when its walls are dissolved by the action of water. Possibly further search will show some trace of an annulus in the earlier stages of the sporangium, but I could discover none, either in the young or ripe sporangia.

As the sporocarp ripens the outer cells become very hard, especially the first layer of hypodermal cells (Fig. 12, b.), whose walls become finally so much thickened that the cell cavities are almost completely obliterated. The second hypodermal layer also has its walls more or less thickened, but not nearly to the same extent.

The ripe sporocarp is about 3 mm. in diameter, and the peduncle about as long and bent downward, so that the sporocarp is partially or completely buried in the earth. When perfectly ripe it splits into four valves corresponding to the lobes or leaflets of which it is made up. This splitting follows the median line of the partitions in the sporocarp.

A comparison of the foregoing statements with the corresponding points in the development of *Marsilia*, so far as the latter is known, show, as might be expected, close resemblances. There seems no doubt that the sporocarp is simply a portion of a leaf, bearing much the same relation to the sterile part that the fertile pinnæ of *Ophioglossum* or *Osmunda* for example, do the sterile part of the leaf. We may perhaps more aptly compare it to such a fern as Onoclea, which is really more nearly related. The structure of one of the spore-bearing leaf segments of *O. sensibilis* for instance, is very similar, indeed, to the sporocarp of *Pilularia*, except that the sporangia are borne upon the lower and not upon the upper side of the leaf. As the Marsiliaceæ are in all probability descendants of forms related to the Polypodiaceæ, the origin of these peculiar points is probably to be looked for in forms having fertile leaves of a type similar to *Onoclea*.

On comparing *Pilularia Americana* with *P. globulifera*, of Europe, less difference was found than is generally supposed.* Except the longer peduncle of the fruit of the former and a slightly diminished development of the wall of the macrospore, I could see no difference. In size my specimens were little, if any, inferior to specimens of *P. globulifera* studied by me in Europe, either as regards the leaves or the sporocarp; and, almost without exception, the sporocarp was four-chambered as in that species, instead of three-chambered as described in the text-books. The absence of

* Goebel, L. c., p. 240. Underwood, "Our Native Ferns and Their Allies," 3d. ed., pp. 126–127. Watson, "Botany of California," Vol. ii., p. 352.

a well marked constriction in the macrospore is due simply to a slightly diminished development of the outer layers of the spore-wall in the upper part of the spore, and a trace of this can always be found in the older spores. At any rate the two species must be regarded as very closely related.

Explanation of Plate CXLVI.

The magnification is indicated before each figure.

Fig. 1. The base of a very young fertile leaf of *Pilularia Americana*, showing the beginning of the sporocarp, m. its apical cell.

Fig. 2. Longitudinal section of an older sporocarp—F. F. two of t e young lobes.

Fig. 3. A similar section of a somewhat older sporocarp.

Fig. 4. A still older sporocarp, in which the cavities are well developed.

Fig. 5. Longitudinal section of on older sporocarp, including the peduncle. S. S. sori; H. hairs; fb. fibro-vascular bundle of the peduncle.

Fig. 6. Longitudinal section of about the same age as in Fig. 5, but at right angles to the peduncle.

Fig. 7. Longitudinal section of the young sorus, a. b. c. young sporangia.

Fig. 8. Transverse section of an older sporocarp, showing the four cavities.

Fig. 9. A single cavity from a somewhat younger one.

Figs. 10, 11. Young sporangia, t. the tapetum.

Fig. 12. Part of the wall of a nearly full grown sporocarp, a. b. c. the outer thick-walled cells.

Free Nitrogen Assimilation by Plants.

By H. W. Conn.

The study of bacteriology has introduced to us an entirely new realm of knowledge. Twenty-five years ago the scientific world had little conception of the great change that was to be made in our knowledge of the processes of nature by the development of the study of micro-organisms. That bacteria were the cause of certain diseases was even then strongly believed by many and had been definitely proved in a few cases. But that micro-organisms, in general, lay at the foundation of many of the most important physiological processes of nature was not even dreamed of. The difficulty of research in this line made it possible for only a very

few to accomplish anything. About ten years ago Robert Koch invented a method of obtaining pure cultures which has placed this line of investigation within the reach of all. The simplification of the methods of obtaining pure cultures has produced an immense stimulus in this branch of study and has turned hundreds of observers towards investigation in this direction. The study of the last ten years has been modifying our ideas with marvelous rapidity. That bacteria produce disease is demonstrated beyond question, but we are beginning to realize that this is only a small part of the purposes they fulfill. We are learning that it is to the action of these organisms that many of the normal processes in nature are due, and that it is to their agency that the growth of plant life of the higher orders is largely indebted. One of the most recent and most surprising discoveries has been the relation of bacteria to the process of nitrogen assimilation.

It is well known to all botanists that nitrogen is an absolutely necessary food for plants and animals. It is known further that the animal kingdom obtains all of its nitrogen from plants, and that plants obtain their nitrogen from the soil in the form of certain salts, the chief of which are nitrates. Now, it is an undoubted fact, that the nitrogen factor of the soil upon which plants can depend, is little by little becoming exhausted through various agencies. In the first place, all of the nitrogenous parts of plants which are used by man as food, find their way eventually into the sewage, thence to the river, and finally to the ocean; and once reaching the ocean, the nitrogen is lost, so far as the terrestrial vegetation is concerned. Moreover, it has been shown that the various processes of putrefaction are slowly turning the complex nitrogen compounds into simpler ones, and eventually eliminating the nitrogen into the air in a free form. Inasmuch as all organic compounds, animal and vegetable alike, are subject to these putrefactive agencies, it is evident that a large amount of the nitrogen factor of the soil must, in this way, pass out into the air as free nitrogen. The extent of this loss is unknown, but it is doubtless considerable. Plainly, unless there is some way of getting the nitrogen back from the air to the soil again, the soil is doomed to exhaustion. But it has seemed to be the result of many experiments that plants in their ordinary vegetation are capable of ob-

taining nitrogen from the soil alone, and are unable to use the free nitrogen of the atmosphere. Putting all of these facts together, it has seemed to science that the nitrogen store upon which plants can draw is being used up and must be sometime exhausted, thus putting an end to vegetation.

Practically our agriculturists have for some time experienced the difficulties arising from this source. Many soils under long cultivation have become largely exhausted of their nitrogen supply, and the farmer appreciates more and more the necessity of nitrogen fertilizers. These are now brought from long distances. The nitrate beds of Chili and the guano beds of the South Pacific are the chief stores from which this valued food is obtained. But even the nitrogen beds have their limits, and as the need for nitrogen on our cultivated soils becomes greater through exhaustion, the price of nitrogen must become greater also. One writer has said that the explosion of powder in a gun does more injury than the bullet. The latter only kills a man, the former aids in in using up the nitrogen store which cannot be replaced and is a lasting injury to mankind. It is very plain from all of this that there is a great need for some means of obtaining nitrogen for our soils besides the store of nitrates in our nitrate beds. Curiously enough, the bacteriologists are to-day pointing out the method by which this problem can be solved.

As mentioned above, it was the conclusion of many experiments that the higher plants cannot make use of free nitrogen from the air. Up to 1880 all experiments seemed to point to the same direction. At about that period, however, experiments with certain of the legumes began to show an increase in the nitrogen in plants beyond that which was fed to them in their food. The experiments were at first rather indefinite and strongly denied, but as the decade from 1880 to 1890 passed they became more numerous and conclusive until, finally, it was a definitely established fact that many of the legumes can in some way obtain nitrogen from some source besides the soil. In 1888 Hellriegel and Wilfarth, in a series of careful experiments upon the subject, studied the relation of this nitrogen assimilation to the production of tubercles upon the roots of plants. Pea plants and other legumes have been for a long time known to develop small nodules

on their roots, and experiments of Hellriegel and others showed a parallel between the development of these root tubercles and the power of obtaining nitrogen in large quantities. It was Hellriegel, also, who first demonstrated that these root tubercles were abnormal products on the roots of the pea, produced there by certain organisms in the soil. Hellriegel found, for instance, that peas growing in sterilized soil produced no tubercles and fixed no nitrogen, while peas growing in a similar sterilized soil but watered with water in which ordinary soil had been standing for awhile (soil infusion), did develop tubercles and fixed nitrogen. The same soil infusion when sterilized was not able to cause the production of tubercles. From all of this it was evident that the tubercles were produced upon the roots of the peas through the agency of some of the organisms in the soil.

A microscopic study of these root tubercles soon attested the same conclusion. It was found that the tuberacles were filled with small organisms related to bacteria, and that the development of the tubercles was parallel to the developement of these organisms. The organisms are somewhat different from normal bacteria and have been called bacteroids.

According to the investigations of Prazmowski in 1890, the development and growth of the tubercles are as follows: *Bacterium radiciola* lives normally in the earth and collects in numbers on the outside of the roots of various legumes. Some of the organisms succeed in forcing their way into the tissues of the young roots, though they are not able to pierce the older roots. For a while they may remain in the root as free bacteria, but the plant plasma seems to exert an injurious influence upon them, for very soon a thin membrane is formed around the bacteria masses, inclosing them like a pouch. Prazmowski thinks that this membrane is a product of the bacteria themselves, formed for the purpose of protecting them from the injurious action of the plant tissue. The bacteria, which do not succeed in getting into one of these pouches, soon cease to grow and degenerate into irregular forms called bacteroids. The bulk of the bacteria, however, become inclosed in the membrane, after which they continue their growth with much vigor. The pouches begin to grow in thread-like masses, and these make their way among the cells of the root.

The thread branches more or less as it lengthens, and its various filiments grow through and between the cells, soon permeating the root with a fine, branching filament, which looks much like the mycelium of a mould. This bacteria pouch has been regarded as the hypha of some low fungus, but instead of being a mycelium growth of a mould the thread is nothing more than a large branching colony of bacteria enclosed in a thin membrane.

The growth of this colony of bacteria among the cells of the root stimulates these cells to an unusual growth. They multiply more rapidly than usual, and thus soon produce a swelling on the root which is the beginning of the tubercle. While this rapid multiplication of root cells is going on, the bacteria pouch continues to grow and swells out into rounded vesicles within the cells which lie at the center of the forming tubercle, until most of them become filled with these expanded portions of the bacteria thread. Meantime the root cells of the plant have been rapidly growing, and form around the cells containing the bacteria, several layers of smaller cells, which develop into a hard, corky covering, forming a coat around the tubercle. This seems to be impervious to the bacteria thread, and confines the bacteria within its limits.

The bacteria colony now undergoes a change. Although Prazmowski has not been able to follow the details of the process, it is thought that the vesicles in the central cells swell until the membrane covering the bacteria is so thin that it bursts, and the bacteria are themselves extruded into the plasma of the root cells. At all events the vesicles disappear and there appears in their place what is called the bacteroid tissue. His interpretation is that the vesicles burst, and the bacteria coming into the cell plasma are immediately checked in their growth by the injurious influence of this plasma and begin to undergo involution changes. Instead of multiplying in the normal manner, they assume various abnormal forms which have no further power of growth. They become, in short, the bacteroids which have been found by many observers, filling the central cells of the tubercle. The bacteria retain their power of growth only so long as they remain in the protecting covering of the membrane.

The tubercle by this time is pretty well formed. The outer cells have undergone quite an extended growth and differentiation,

so that the tubercle is really a structure of a rather high grade of plant tissue. The tubercle itself is thus really a growth of the root cells of the plant and not a growth of bacteria. In the center of this mass of plant tissue are a large number of cells which are completely filled with the so-called bacteroids. These bacteroids give to the tubercle at this stage a flesh-red color. Some of these central cells are so completely filled with them that nothing else can be seen, while others may still show the cell nucleus. In others spaces begin to appear in the body of the cell. The appearance of the spaces marks a new stage in the history of the tubercle and indicates that the bacteroids are beginning to be absorbed by the plant. The cell plasma soon assumes a network structure, and from this time the bacteroids entirely cease their activities and begin to disappear rapidly. After a little they are completely absorbed by the substance of the plant, and the tubercles are left as empty pouches. The tubercles have now changed their appearance again and assume a somewhat grayish green color.

This practically ends the history of the tubercle. In most cases some of the bacteria seem to remain within their original membrane and, therefore, are still capable of growing. These may or may not set up a secondary growth, but it amounts to little, for by this time time the plant has usually blossomed, ripened its seeds, and the root is beginning to die. The tubercle is immediately attacked by the putrefactive bacteria in the soil and becomes decomposed.

Since the work of Prazmowski other observers have studied the same problem. Pure cultures of the root organism have been obtained and used by artificial inoculation. Water cultures have been made where the process can be better studied. The general result has confirmed the idea above outlined, and proved conclusively that the tubercles are the result of the action of micro-organisms in the soil.

There has been more or less dispute in regard to the actual nature of these organisms. For a time they were thought to be parts of the roots of the legumes, but this idea was soon abandoned, and they were regarded as the hyphæ of moulds. Later their relation to bacteria was rendered extremely probable, and

this is the generally accepted view to-day. The organisms do not act like ordinary bacteria, since they grow in a different way and have a somewhat different form. It is a matter of comparatively little importance, however, whether the organisms are regarded as true bacteria or simply as related organisms. The significant fact is that they are colorless microscopic organisms, living in the soil, belonging to the low fungi and having the remarkable functions above pointed out.

The work of the last two years has shown further that there are a number of different species of these root organisms and that different species of legumes are associated with different species of these bacteroids. The organism which produces the root tubercles of the lupine will not produce the root tubercle of the pea, and, although the subject has not been as yet very thoroughly cleared up or studied very widely, it seems that nearly all of the different species of legumes are associated with different forms of organisms in the soil. It has followed from this that special soils are especially adapted for the growth of certain species of legumes. A soil for instance in which the lupine has been growing is much better adapted for the production of tubercles on lupine roots than it is for the production of tubercles on the roots of the pea, simply because the soil is already filled with the organisms which can grow in the lupine and not yet provided with that growing in the pea. It requires thus a culture of a year or two to develop in the soil a sufficient quantity of the appropriate species of bacteria to render the growth of any species of legume especially advantageous. The special work of bacteriologists at the present time is turned largely in the direction of determining the facts in regard to this matter of bacteria species associated with the different species of legumes.

It is plain from the above that the production of root tubercles is not a normal feature of the life of the pea plant, and that the bacteria have some peculiar relation to the higher organism. It is, however, hardly proper to regard their relation as that of a parasite and its host. It is true that the bacteria grow in the root of the legume and doubtless obtain sustenance therefrom, but the higher organism does not suffer from the parasitism and the relation of the two organisms is rather that which is known as symbiosis, i. e., a

relation in which each organism gains advantage. So far as the bacteria are concerned, they doubtless gain a place for developing a breeding pouch, and perhaps gain some sustenance from the root of the pea. So far as the pea plant is concerned, the presence of the organism makes possible the assimilation of free nitrogen. In all of the experiments which have been carried on it has been found that the production of the tubercles is necessary to enable the legumes to assimilate nitrogen. Where the legumes develop without tabercles on account of the lack of bacteria in the soil, no nitrogen was assimilated, and where the tubercles were very abundant, much nitrogen was taken from the air. It is plain then that the pea plant obtains a considerable advantage from its association with the lower organism.

As to the method by means of which this association of organisms extracts the free nitrogen from the air, we are as yet in the dark. That it is free nitrogen that is assimilated by the plant and not combined nitrogen, has been demonstrated by the experiments of the last two years, but where the nitrogen is first fixed is as yet a question. It has been suggested that the bacteria themselves take the nitrogen out of the air and store it up in these tubercles; it has been suggested that the bacteria stimulate the legumes in such a way as to enable the legume to seize the free nitrogen from the air and store it in the roots; and it has been suggested that the assimilation of the nitrogen is a matter of the combined action of the bacteria and the legume life together. Which of these possibilities is the proper one science has not yet indicated, but it has been satisfactorily proved that through the combined life of the bacteria in the root of the pea plant nitrogen is taken from the air and stored up in the roots of the pea plant in the form of nitrogen compounds of high complexity.

The work on this subject of nitrogen assimilation at the outset seemed to indicate that the family of legumes alone possess the power of absorbing nitrogen from the air. Undoubtedly, this family possesses this power to a greater extent than any other family of plants, but it is still a question whether the same power is not developed in certain other plants. Upon this matter experimenters are not in agreement at the present time, for while some experiments have plainly pointed to a nitrogen assimilation of non

legumes, the results are somewhat indefinite, and it is difficult at present to determine the truth. Be this as it may, the fact still remains that it is to legumes chiefly that we must look for the restocking of our soils with nitrogen.

It has been a difficult matter to make any very valuable quantitative tests upon this power of bacteria and legumes to assimilate nitrogen from the air. Still, within the last year or two quite a number of extended experiments have been turned in this direction. Experiments have shown in the first place, that in regard to some of the legumes at least, a greater amount of nitrogen can be assimilated through the agency of the bacteria alone than can be assimilated by the same plants if they are fed with nitrogen foods. The same species of legumes are grown under two conditions, in both cases supplied with the organism which produces its root tubercles, and in the one experiment fed with nitrogen foods in the form of nitrates, and in the other not thus fed. The result shows a considerable difference to the advantage of the plants that are not fed with nitrates. The amount of nitrogen which can be assimilated and fixed in the soil by these legumes is really very great. In experiments with scarlet clover it has been found that a plant will assimilate from the air more than twelve times the amount of nitrogen in the seed. In one of the most recent experiments it has been found that by the use of beans a single crop assimilates and fixes in the soil 225 pounds of nitrogen per acre, equivalent to about 1400 pounds of nitrate of soda. These figures are very striking and suggestive, and they show plainly what a very great agent in the fixation of nitrogen the legume plants can become when properly associated with their appropriate species of bacteria. Peas, beans, cow peas, alfalfa, vetch and clover appear thus far to be the most valuable plants for this purpose, but other legumes serve the same purpose.

These experiments promise to be of the most incalulable value to the agriculturist and to the agricltural interests of the world in the future. They offer to our farmers a means of getting nitrogen without going to the expense of buying it, of enriching their soil by simply cultivating upon it plants which experiment has shown most appropriate to the soils in question. They emphasize the value of clover as a crop to precede wheat, and ex-

plain the great nutritive value of clover hay. Indeed, bacteriologists are now beginning to wonder if it has not been through the agency of these micro-organisms that the large nitrate beds of the world have been deposited. The nitrate beds of Chili are vast in extent, and it has been already suggested that these beds owe their deposition to the agency of some microbes, to bacteria associated with higher plants which have grown in these localities in past ages. If so, we see even more forcibly that at the very foundation the life of the world is dependent on the action of bacteria.

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On the Casting-off of the Tips of Branches of Certain Trees.—Part II.

BY AUG. F. FOERSTE.

(PLATES CXLVII. AND CXLVIII.)

In "Gray's Structural and Systematic Botany," page 44, may be found the following passage:

"When a terminal bud is formed* this is commonly the strongest or among the stronger. But in many cases it habitually or commonly *fails to appear.*† In the Elm the bud axillary to the last leaf of the season takes its place. In the common Lilac a pair of buds, which were in the axils of the uppermost of the opposite leaves, seem to replace the terminal bud, which *seldom*† develops."

On page 49 are the following words:

"In other cases, on the contrary, the branches grow on *indefinitely* until arrested by the cold of autumn; . . . the later-formed upper portion most commonly perishing from the apex downward for a certain length *in the winter.*† The Rose and Raspberry, and, among trees, the *Sumac* and *Honey-Locust*, are *good illustrations of this sort.*"†

In the September (1892) number of this journal the writer had occasion to show that the reason why the terminal bud *fails to*

* Incidentally the author is chiefly referring to the scaly buds of ligneous plants.

† Not italicized in the original.

appear in some ligneous plants was because at an earlier date, before terminal scaly buds were formed, the tips of the branches had fallen off at well marked joints. This was shown to be the case not only in the Elm, but also in other species.

In the common Lilac the terminal scaly buds fail to appear, simply on account of the fact that at an early date the tips of the branches wither, though remaining more or less attached to the stem.

As regards the perishing from the apex downward for a certain length *in winter*, this is no doubt true of the Rose and the Raspberry; but in the case of the Sumac and Honey Locust it just as certainly is false, since in the case of both these plants the tips of the branches are cast off at well marked joints before the close of summer, as will be seen in the following paragraphs.

The preceding passages have not been quoted in a spirit of criticism, but in order to show that the subject of the casting-off of the tips of branches, although a common occurrence, has not yet received all the attention it deserves.

In the present paper it is desired to emphasize two facts, that this casting-off of tips occurs in widely different families, and that in certain minor groups of plants, or sections of families, the habit is common to many species, while in other groups scaly terminal buds are the rule. It is believed that the presence or absence of terminal scars on winter twigs has additional interest, since their existence may assist greatly in the determination of trees in winter, as suggested by the writer in another paper recently.

In the following notes, unless otherwise specified, the observations refer to plants growing in the vicinity of Dayton, O., the examinations and figures were all made during the first week of August.

Tilia Americana (Fig. 5). See, also, Fig. 6, Plate CXXXII., of this journal, showing the same species during its winter months. Fig. 7 of the same plate shows one of the very few tips of *Tilia platyphyllos*, still remaining attached to its branch during the last days of May, at Heidelberg, Germany.

Ptelea trifoliata (Fig. 20). The petioles are light green, the bark of the twigs is of an almost chocolate brown color. The ter-

minal scar is roundly angulate, similar to that of *Rhus glabra* and *Gymnocladus dioica*. *Xanthoxylum Americanum* has terminal buds rising but little above the surface of the stem, and covered with a thick coating of short red hairs.

Ailanthus glandulosus was figured (Fig. 5) on Plate CXXXII. of this journal.

Ampelopsis quinquefolia (Fig. 26). This plant is a curious case of sympodial growth. After a node bearing a leaf but no tendril, there are quite normally two nodes bearing a leaf and also a tendril, then follows a node again without a tendril. The leaves have the appearance of being alternate, distichous. Where there is no tendril the leaf axil quite commonly contains a well developed scaly bud. Now it was a curious fact in all the observed cases that where the tips of the branches were absent, the scar belonged to that node where there should be no tendril. This is well worthy of note since in August many of the tendrils of this plant have fallen off and left scars, though these are much smaller than the terminal scars. In case of the grape it was very difficult to get satisfactory tips of branches, since these tips were still growing, or had been eaten off by animals. In a very few cases I noticed, as in *Ampelopsis*, a scar where the node should bear no tendril, and I have figured one of these (Fig. 24). *Celastrus scandens* in September showed terminal scars only on the shorter, stronger branches, but later, in November, almost all branches showed terminal scars.

Æsculus glabra (Fig. 14) and *Æsculus Hippocastanum* (Fig. 4 of Plate CXXXII.), will be discussed at the close of this paper. *Staphylea trifolia* (Fig 12, see also Fig. 3 of Plate CXXXII. of this journal), has a very peculiar terminal scar, owing to the fact that the uppermost pair of buds have so compressed the sides of the terminal scar as to very much decrease its diameter in one direction and to give it the form noticed in the figure. The central portion is depressed. The figure shows the stipules. Species of *Negundo* and *Acer* have terminal scaly buds.

Rhus glabra, (Fig. 21) has a roundly-angulate terminal scar. The fruited tips of this species remain on the plant all winter, dying back as far as the first leaf bud, as may be expected in the case of any fruited tip of a stem, which did not fall off after the

seeds were ripened (as is usually the case). All branches not terminated with flower clusters, cast off their tips at well marked scars. *Rhus copallina* sheds a tip about 15 mm. long, consisting of three or four leaves with very hairy, strong petioles and very small and narrow, almost needle-like leaflets, 3–4 mm. long. *Rhus aromatica* (Fig. 18) casts off its leaves at a point a little above the base of the petiole; the portion remaining attached to the stem is rather appressed, and hides the subtended bud during its earlier development. The terminal scar is found at the end of a round, rod-like tip, which may be produced quite a distance beyond the point of attachment of the uppermost remaining leaf. *Rhus radicans* has terminal scaly buds.

Robinia Pseudacacia (Fig. 3). The terminal scar is somewhat irregular, owing to the angulate character of the branches. In consequence of shrinking, subsequent to the falling off of the tip, the terminal scar is quite puckered up, as is also the case with *Gleditschia triacanthos*. The figure shows the top of the branch still attached, but withering, and the position of the scar is already indicated by the fact that the yellow color of the withering part stops abruptly at a plane bounding the green portion further down which is to remain. Even before the slightest withering has commenced, it is already possible to see at what node the plane of separation is to be by the fact that whereas the last leaf of the remaining portion develops rapidly into a full sized leaf, the next succeeding leaf which is to fall off shows retarded growth at a very early stage, while the tip is still green.

During the first week of August all the tips of the higher branches had fallen off. This was true also of the lower branches, where the tree was fully developed. Occasionally, however, the lower branches were more vigorous, and were still continuing growth, or were preparing to also cast off their tips. From one of these lower branches the figure was taken. In young growth, or in fresh shoots from cut down stumps, the tips of the branches were often present in the middle of August, but in the middle of September all the tips seemed to be shed. In the axils of the leaves are little raised circular scars, left by axillary buds which are cast off at a very early stage of their development. In the figure these are shown in all except the lowest axil. In very vigorous shoots

these buds develop into leafy branches during the same season. It is especially to be noted that the lower branches of a tree are often still growing after the tips of all the upper branches have been cast off. *Gleditschia triacanthos* (Fig. 6) shows all the features just noted of *Robinia* The only bud which is visible in the axil of the leaves is extra-axillary, being situated a short distance above the axil. This bud is cast off as a rule, at an early stage, or on very vigorous branches, develops into a leafy branch during the same season. The extra-axillary compound thorn of this tree is morphologically equivalent to these buds. As a rule the thorns are developed chiefly along the middle portion of each year's growth, but occasionally the thorns occur even at the uppermost axils destined to remain. In that case the terminal scar is formed just above the last thorn. The visible buds therefore, of both *Robinia* and *Gleditschia*, (unless they be represented by thorns or develop into leaf branches the same season) are cast off. The buds which continue the growth of the branch are hidden away beneath the petioles of the leaves at this time of the year, so that the cast off buds are in reality the uppermost ones of a series of a superposed bud. *Gymnocladus dioica*, (Fig. 7) has a roundly angulate terminal scar. The superposed buds are sunken in pits, and often drop out. This is especially true of the largest bud in the axil of the last remaining leaf, this bud being the uppermost one of its series, and hence, lying next to the terminal scar. *Cercis Canadensis*, (Fig. 2) has a little rounded terminal scar. The last remaining leaf has a petiole placing itself in line with the stem, as is quite commonly the case where the phyllotaxy is alternate and distichous. A glance at the figures on the accompanying plates will readily show this. It is not uncommon to find more than one bud even in the last remaining axil, and the larger of these superposed buds, the upper one of the series, lies then against the terminal scar.

Prunus Americana (Fig. 19) shows very distinct terminal scars. It is more usual for ligneous Rosaceæ to have terminal scaly buds, so the present exception is worth noting.

Calycanthus floridus (Fig. 25) has well marked terminal scars.

It was impossible to determine satisfactorily whether *Sambucus Canadensis* ever had terminal scars or not. In the

early days of August many branches were still growing. Later in the year some branches were found terminated by scars, but these seemed to be caused by the breaking off of the fruited flower clusters at the ends of the branches. *Lonicera flava* (Fig. 22) has the tips withering away, but not falling off at a well marked scar. The dried up tips may be seen between the upper pair of leaf buds.

Cephalanthus occidentalis has its branches almost invariably terminated by inflorescences, a part of which have never developed into flowers. The few tips with flower buds show shriveled-up leaves at the ends of stems, drying back a little, thus giving rise to sympodial growth.

Catalpa speciosa, Warder, was figured (Figs. 1, 2) on Plate CXXXII. of this journal. During the early days of August most of the tips had been cast off; here and there the very short, shriveled remains embracing only a few nodes were still attached to the stem. The tips of a few of the lower branches were growing vigorously and did not lose their tips until later during the month. It was impossible to get satisfactory specimens from *Tecoma radicans*. Many branches were still growing when examined. Where there were terminal scars it was often possible to ascribe these to the falling of the flower clusters, where fruiting had not set in. One case was found where apparently the leafy tips of a branch had fallen off, but the case was not altogether satisfactory.

Diospyros Virginiana, with its shriveled-up tip, was figured (Fig. 9) on Plate CXXXII. of this journal. Terminal scars are also common.

Ulmus Americana (Fig. 10 and Fig. 8 of Plate CXXXII. of this journal) and Ulmus fulva (Fig. 8) both lose the tips of their branches, indeed, quite early in the year. *Ulmus campestris* was observed at Heidelberg, Germany, to have lost about one-third of its tips during the last week of May, although the future plane of separation was becoming visible in the remainder. *Celtis occidentalis* (Fig. 11) also shows the terminal scar. A little feature was noted which will well serve to readily distinguish this tree in winter time, when other aids are not at hand. The scaly bud in the axil of the last remaining leaf is quite strongly bent away from

its leaf and recurved over the terminal scar, the bud itself giving evidence of this curvature. The appressed nature of the remaining buds is also worthy of note.

It has already been remarked here several times that the lower branches of trees seem to be more vigorous and frequently are still growing when all the upper branches have already cast off their tips. In the case of *Celtis occidentalis* this found expression in another way. A number of trees were found early in August, on the Germantown road, on the way to the Soldiers' Home, which had lost all the tips of this year's normally produced branches. But in the case of many of the lower branches the uppermost scaly bud had not waited till next year for its development, but had renewed growth during the same season. In August the tips of even this second crop of branches had been already cast off in many cases. But here and there the tips were still attached, though turning yellow in color and giving evidence of the location of the future plane of separation. The tips included only a few nodes, and were 4-6 mm. long.

Morus rubra (Fig. 4) has well developed terminal scars, with a depressed central portion. The milky juice of the bark will also serve to distinguish the species when the leaves are gone. In winter the twigs of *Tilia* have a similar appearance, but its terminal scar has no depressed centre.

Ioxylon pomiferum (Fig. 1) was found during the first days of August to have cast the tips of all the more mature branches. But where the hedges had been cut and a fresh crop of branches had appeared many branches were still growing, and the tips were therefore vigorous. Later in the year this younger crop of branches also lost its tips. In the more mature trees all the branches had lost their tips in September.

Platanus occidentalis (Fig. 9) is one of the more interesting of trees which shed the tips of their branches, owing to the fact that the lower part of the connate stipules forms a sheath embracing the stem. That portion of the tip which is destined to fall off, ceases growth quite soon and withers; being surrounded by the sheath of the stipules, it may be either entirely included within the same or it may project a little from the sheath (Fig. A). After a time both the tip of the branch and the surrounding stipular

sheath fall off and a terminal scar is left (Fig. B). Both stages were visible during the first week of August. The uppermost subpetiolar bud continues the growth of the branch; this is, however, an axillary bud. It does not become visible until the leaves of that part of the stem which remains have fallen off.

Corylus Americana (Fig. 15) casts off its tips while they are still small. One of these tips is here figured. The axillary scaly buds are small and oval or rounded, showing but three or four scales exteriorly; the base of the leaves is distinctly and strongly heart shaped. *Ostrya Virginica* (Fig. 16) has long, pointed axillary scaly buds, showing six or more scales exteriorly. The petioles about equal the buds in length. The lower half of the leaves is wedge-shaped, with a narrow base. The tip of the leaves is long, almost awl-pointed. *Carpinus Virginiana* (Fig. 17) has ovate obtuse scaly axillary buds. The petiole of the leaves is more than three times as long as the subtended scaly buds. The lower half of the leaves is much less evidently wedge-shaped, and the base is more rounded than in the last species. The short, almost abruptly pointed tip of the leaves is quite a useful distinguishing feature. In all three species just enumerated, the terminal scar is very tiny, and often difficult to find. Their leaves are alternate, and distichous. In the scaly buds this phyllotaxy is obscured by the fact that most of the scales represent stipules, and hence occur in pairs; on this account the distichous arrangement of the elements of the bud cannot be readily made out. This characteristic will serve to distinguish these genera from the ordinary distichous plants during winter months. Species of *Quercus*, *Castanea* and *Fagus* show terminal scaly buds.

Some species of *Salix* show terminal scars (Fig. 13) Observed species of *Populus* have terminal scaly buds.

Some species of *Smilax* show at times a short shriveled up remnant of the tip of the branches, at others a terminal scar (Fig. 23).

The best cases of groups of plants casting off the tips of their branches quite generally are the Leguminosæ, Urticaceæ, the Carpineæ among Cupuliferæ, perhaps the Bignoniaceæ, and to a lesser degree the genera *Tilia*, *Staphylea* and *Aesculus*, the sections *Sumac* and *Lobadium of Rhus*, possibly the Vitaceæ in part, and apparently a fair proportion of the species of the genus *Salix*.

The preceding list includes 23 genera in which the casting off of the tips has been noted with certainty. The list is by no means complete for the northeastern United States, but includes chiefly such plants as the writer could find growing near Dayton, Ohio, and use for the purposes of illustration. They certainly indicate that the method of securing determinate growth by the casting off of the tips of branches (usually early in the summer, and quite generally before the first of August) is a fairly common and normal one, and as such is worthy of mention in discussions of the habits of trees.

One of the most interesting features about the growth of trees is the shortness of the period of development of the twigs of the year. The winter months at Bainbridge, in Georgia, have been unusually severe this year (1893), so that the vegetation was decidedly backward. At the beginning of March very few leaves had made their appearance on trees. At the close of this month quite a number had already developed their terminal scaly buds, or had begun to cast off the tips of their branches. In some cases the terminal buds were seen in but little more than two weeks after the leaves began to appear. The following notes were taken at the end of March: *Æsculus Pavia* had well formed terminal buds; the exterior pair of scales of these buds show a leaf-like tip at first, but this falls off at an early date at a scar having about the level of the top of the bud at this time. Careful search for terminal scars did not reveal any which could not be referred to the casting off of flower peduncles after the period of flowering. *Æ. glabra* is probably in the same case, and it is equally likely that the supposed terminal scars of *Æsculus Hippocastanum* are caused by the falling off of flower peduncles, although I was trying to guard against this error at the time the first part of this paper was written.

Enonymus Americanus in one case had developed the internodes of the scaly bud so much as to elevate the innermost scales 120 mm. above the base of the former winter bud. The leafy portion was 300 mm. long and consisted of 6 pairs of leaves. The terminal bud was already formed. *Acer saccharinum, Hamamelis Virginica, Cornus florida* and *Viburnum prunifolium* had already terminal scaly buds. The less vigorous branches of *Juglans nigra*

had ceased producing new leaves. Several species of oaks had already developed far enough to show terminal buds on many trees while on others the leaves had not yet begun to make their appearance.

Quercus nigra furnished a good example of a plant which has most of the nodes for next year's growth already indicated in the bud. The stipules of 14 leaves showed distinctly that they had formed part of the scaly bud during the winter, and this was, not improbably, also true of most of the stipules farther up. It is evident therefore, that the growth of the new crop of branches was little more than the development of the leaves whose position was already determined in the winter bud. Many beeches, *Fagus, ferruginea*, had formed their terminal buds, although these were still very small and did not at all resemble the winter buds.

Regarding the early development of terminal scaly buds it may be observed that at the time of their detection they are far from being fully developed, and they are often still very dissimilar from their fully grown winter form. Moreover at the time of their first detection the internodes of the new year's twigs have not yet finished their growth, so that the terminal bud is already indicated at a time when the full length of the twig has not yet been attained.

Vaccinium tenellum at the end of March was shedding the tiny tips of the branches consisting of two or three very minute leaves. *Carpinus Virginiana* was shedding tips about 3 mm. long, sometimes longer, of which the leaf elements could be recognized more readily. Although the old branches of *Leucothoe axillaris* gave evidence that they had shed their tips during the preceding year, the new crop of branches had scarcely started in March.

Both methods of terminating the growth of the year, that by means of the formation of terminal scaly buds, and that of casting off the tips of branches, are employed very early in the year, as just seen. When, however, a ligneous plant does not terminate its growth until late in the year, the casting off of the tips of the branches seems to be the rule, where killing back of the tips does not obtain. It would be interesting to learn how many ligneous plants develop terminal scaly buds after the first of June, for example, in a more northern climate. It is believed that the casting

off of the tips of branches would be much more common after that date.

Description of Plates CXLVII. and CXLVIII.

Fig. 1. *Ioxylon pomiferum;* with a rounded protuberance at the side of the bud.

Fig. 2. *Cercis Canadensis*; with superposed buds in the last axil.

Fig. 3. *Robinia Pseudacacia;* with the tip destined to be cast off still in position, but with the future plane of separation already indicated; at *a* is the upper one of the series of superposed buds, destined to be cast off, and to leave a small protuberance as at *b*.

Fig. 4. *Morus rubra;* with magnified view of the terminal scar, with a depressed centre.

Fig. 5. *Tilia Americana.*

Fig. 6. *Gleditschia triacanthos;* at *a*, is the upper one of the series of superposed buds destined to be cast off, as at *b;* the remaining buds of the series are usually all sub-petiolar; in the axil of the last remaining leaf, the figure shows the next lower bud, just peeping from beneath the base of the petiole; an upper view of this portion of the branch, somewhat enlarged, is added. The thorn is the equivalent of the upper superposed bud which usually drops off before the close of August.

Fig. 7. *Gymnocladus dioica*; with only the uppermost of the superposed buds of the last remaining axil visible in the figure.

Fig. 8. *Ulmus fulva.*

Fig. 9. *Platanus occidentalis*: two figures; the upper one still retaining the shriveled up tip of the branch, with the enclosing stipules belonging to the last remaining leaf. In the lower figure these have been cast off.

Fig. 10. *Ulmus Americana.*

Fig. 11. *Celtis occidentalis;* the upper-axillary bud strongly recurved, a distintinguishing feature of this genus.

Fig. 12. *Staphylea trifolia;* showing the stipules belonging to the upper pair of remaining leaves; also a magnified end view of the terminal scar.

Fig. 13. *Salix.*

Fig. 14. *Æsculus glabra;* when the end of the twig does not fall away, and when there has been no flower cluster, a scaly bud terminates the stem.

Fig. 15. *Corylus Americana;* with a drawing of the small tip which has been cast off.

Fig. 16. *Ostrya Virginica.*

Fig. 17. *Carpinus Virginiana.*

Fig. 18. *Rhus aromatica;* two figures. The branch in most cases is terminated by a flowering catkin destined to blossom next year.

Fig. 19. *Prunus Americana.*

Fig. 20. *Ptelea trifoliata.*

Fig. 21 *Rhus glabra.* The branches are often terminated by the remnants of last season's flower clusters.

Fig. 22. *Lonicera flava*, with the shriveled up tip of the branch adhering.

Fig. 23. *Smilax hispida;* with a terminal scar. Often the tip of the branches simply shrivels up, and a part or all remains attached to the remainder of the stem.

Fig. 24. *Vitis.*

Fig. 25. *Calycanthus floridus.*

Fig. 26. *Ampelopsis quinquefolia.*

In all the figures *t. sc.* indicates the terminal scar; *shr. tp.*, the shriveled tips remaining in case of some plants, and *t*, the scar left by the casting off of the tendrils.

A new Fossil Palm from the Cretaceous Formation at Glen Cove, Long Island.

By Arthur Hollick.

(Plate CXLIX.)

For some years past the writer has been engaged in the study of the Cretaceous formation of this vicinity, particularly on Staten and Long Islands, and a considerable amount of material representing the fossil flora of that formation has been collected. The specimens from Staten Island have already been described,* —those from Long Island it is hoped to describe in full in the near future, but in the meantime it has been thought best to publish in advance the accompanying description and plate.

Probably the greatest surprise experienced in the study of the above mentioned material was in the discovery of an undoubted palm leaf. The significance of this discovery from the geological standpoint need not here receive more than brief mention, as this will be fully discussed elsewhere. It is sufficient to say that the other fossil leaves associated with it show the geological horizon to be the equivalent of the Amboy clays of New Jersey and other middle Cretaceous strata in America and Europe, from none of which have palms been definitely recorded. In fact the presence of palms in lower and middle Cretaceous strata is so rare, if not entirely wanting, that this discovery seems to warrant special attention. They appear in great abundance in upper Cretaceous and Tertiary rocks, and their sudden appearance without any apparent ancestry has always been a puzzle. The significance of the find may therefore be appreciated.

* Trans. N. Y. Acad. Sci. xi. 96–103, Plates i.–iv. and xii. 1–12, Plates i.–iv.

The specimen in question evidently belongs with the tribe Corypheæ, and its nearest living allies are to looked for in the genera *Trithrinax*, *Copernicia*, *Thrinax* or *Serenæa* (*Sabal*). The imperfect condition of our specimen does not admit of accurate comparison, but there seems to be but little doubt that it is allied to this group, and as we find associated with it leaves of trees which demonstrate that they were the ancestors of our living *Liriodendron*, *Platanus*, *Sassafras*, etc., we are certainly within the bounds of reason when we infer that we have here one of the ancestors of our Southern "Palmetto," as I have indicated in the generic name. The specific name has been adopted in honor of Prof. Jas. F. Kemp, of Columbia College, to whom the credit for finding the specimen is due.

Serenopsis, N. Gen.

Leaves small, fan-shaped, deeply pinnatifid, palmately about 18 divided. Rays tapering to acute tips and broadening into blunt wedge-shaped bases.

SERENOPSIS KEMPII. Leaves circular or sub-cordate in outline, somewhat longer than broad, 3 to 3½ inches in diameter. Rays radiating in all directions from the sub-triangular apex of the petiole; confluent for a distance of about ⅛ to ¼ inch from the petiole, then divergent; central ones about 2½ inches long, outer (lower) ones about ½ inch long; average width about $\frac{1}{18}$ inch; margins entire (?); nervation obscure.

Only a single specimen was found. The two figures represent counterparts of the same one.

Botanical Notes.

Scabiosa australis, Wulf.—Mr. Redfield will find on page 46 of the Cayuga Flora a statement of the thorough establishment of *Scabiosa australis*, not only near Farley's Point, Cayuga Lake, but all along the lake shore meadows of Union Springs for five miles. Moreover, a full description of the species is given in the Flora, and the date of its first discovery (the first in America, probably), viz., 1881; also a reference to the possible dissemination of it from the little botanic garden of David Thomas, civil engineer and

clever naturalist, who, with other members of the Society of Friends, made their home in this very locality over eighty years ago. He was the author of *Ulmus racemosa*, a characteristic tree of Central New York. In the herbarium of J. J. Thomas the writer found a specimen of this *Scabiosa* collected from the garden of David Thomas nearly seventy years since. There is no question but that the weed has come to stay. It forms a turf of its own in favorable localities, and is more abundant about Union Springs than ten years ago. I have since found it in the township of Montezuma, twenty miles north.

L. S. Jr. University, Palo Alto. W. R. Dudley.

Amarantus blitoides, Watson.—Mr. Lighthipe's note in the February Bulletin announcing the occurrence of *Amarantus blitoides* in New Jersey within the "one hundred mile limit," prompts me to say that this species is well established within the corporate limits of New York city. It is to be found along the Hudson River Railroad track about Kingsbridge, Mount St. Vincent and Fort Washington, and doubtless at other points even nearer to the city proper. It grows on the gravelly road-bed, sometimes even between the rails, and on the adjoining embankments.

Eugene P. Bicknell.

Death of Dr. Vasey.—Dr. George Vasey, Botanist of the United States Department of Agriculture, died at his home in Washington, D. C., after a brief illness, on March 4th, in his seventy-first year. Dr. Vasey's acquaintance with North American Grasses was probably unequalled by that of any living botanist. All the later years of his life have been devoted to their study, and his publications upon them have been numerous and varied. A sketch of his life will appear in a subsequent issue of the Bulletin.

Dr. Vasey is succeeded by Mr. F. V. Coville, who has been for several years his assistant, and no better choice could have been made in filling the position left vacant. Mr. Coville brings to the post the enthusiasm and activity of youth, high botanical sagacity, tact, a capital scientific education and good administrative ability. He will well represent American Science both here and abroad.

Proceedings of the Club.

TUESDAY, MARCH 14, 1893.

The President in the chair and twenty-six persons present.

The Editor announced that a paper by Prof. L. M. Underwood, on the Bibliography of Hepaticology, would form part 1 of Vol. IV. of the MEMOIRS, and that Dr. Rusby's first publications upon Mr. Bang's Bolivian collections would form the third part of Vol. III.

Dr. Morong exhibited the interesting fruit of a species of the Asclepiadaceous genus *Exolobus* from Paraguay, and remarked upon the habits of the plant.

The following active members were elected: Mr. Theodore G. White, Mr. Louis Froelich, Mr. Rudolph Weber, Mr. Stewardson Brown, Mr. Joseph D. Crawford.

The announced papers of the evening were then read as follows: "Notes on *Cladosporium fulvum*, by Miss Effie A. Southworth. This fungus is a parasite of the tomato plant, most injurious in the winter season to hot-house plants, thus being especially destructive from an economic point of view. The fungus apparently grows entirely between the cells, and commonly makes its appearance protruding through the stomata. The first appearance is that of whitish spots on the under sides of the leaves, which soon turn yellow, yellow spots at the same time developing opposite these upon the upper surface. The Bordeaux mixture is especially valuable in treatment. Miss Southworth presented a very interesting life history of the plant, well illustrated by blackboard drawing.

"Some Theories about Osmosis," by Dr. Emily L. Gregory. This paper will be published in a subsequent issue of the BULLETIN.

"Preliminary Notes on the Atlantic Coast Species of *Polysiphonia*," by Mr. Carlton C. Curtiss.

WEDNESDAY, MARCH 29, 1893.

Vice President Morong in the chair and twenty-eight persons present.

Dr. D. T. Millspaugh of 89 Hamilton Place, Paterson, N. J., and Prof. Elmer E. Sherman of South Orange, N. J., were elected active members.

The following communications were then presented:

By Mr. Arthur Hollick, "On Palm Leaves from the Cretaceous Strata at Glen Cove, L. I." The paper is printed in the present BULLETIN.

By Dr. Thomas Morong, on "The North American Species of *Smilax*." The paper was fully illustrated by numerous specimens and was discussed by Messrs. Hollick, Curtiss and Rusby.

By Dr. Britton and Mr. Kraemer, "On a Collection of Plants made by Dr. Timothy E. Wilcox, U. S. A., in the Vicinity of Fort Huachuca, Arizona." Several species new to the United States Flora were presented.

The presentation by the editor of a copy of Dr. Morong's Monograph of the North American Naiadaceæ, MEMOIRS, Vol. III., Part 2, elicited an expression of thanks from the author to members of the Club for their assistance, by which it had been possible for his work to become published.

Index to Recent Literature Relating to American Botany.

Abutilon—Ueber die Gattung. A Garcke (Engler's Bot. Jahrb. xv. 480–492).

Agave filifera. L. Münzer (Monatsb. Kakteenk. iii. 17).

Note on the flowering of this species in the Berlin Botanical Garden.

Botanical Congress—An International. Chas. E. Bessey (Amer. Nat. 1893, 279).

Dr. Bessey, as Vice President of the Section of Botany, A. A. A. S., has appointed a committee of eleven botanists to arrange for an international Botanical Congress to be held at Madison next August.

Buttonwood.—The. J. T. Rothrock (Forest Leaves, iv. 5, 6).

With a fine illustration of *Platanus occidentalis.*

Catalogue of the Flowering Plants and Vascular Cryptogams, found in and near Lackawanna and Wyoming Valleys, Pa. William R. Dudley and Charles O. Thurston (Wilkes-Barre, Pa., 1892).

This is substantially a reprint of the preliminary list published in 1887 by Prof. Dudley (then of Cornell, now of the Leland Stanford University, Cal.), in the Proceedings of the Lackawanna Insti-

tute of Scranton, altered and enlarged by the addition of species since collected, with the aid of Prof. C. O. Thurston, of the Wyoming Seminary at Kingston. The typography is excellent, and the style of the whole and the paper are all that can be desired. The number of additional species reported is not as great, however, as might have been expected. Of the few rare ones new to Pennsylvania *Pyrus sambucifolia*, Cham. and Schlecht., discovered near Luzerne by Prof. Thurston, who has kindly sent me a specimen, is, perhaps, the most interesting. His description of the spot where it was found excludes all suspicion of escape from culture. The only thing that mars the value of this beautiful catalogue is that no herbarium exists behind it, by which its contents could be verified. T. C. P

Coccocypselum hirsutum (Bot. Mag. t. 7278).

Native of Central America and Trinidad.

Compositæ, Observations on the—III. Edward L. Greene (Erythea, i. 53–56).

Discussion of the characters and relationships of the genera *Coleosanthus* and *Kuhnia*.

Cornels or Dogwoods. (Garden, xliii. 152.) *Cornus florida* is figured, and a number of other species mentioned.

Development of Spermagonia in Cæoma nitens. H. M. Richards. (Proc. Amer. Acad.)

This contribution from the Cryptogamic Laboratory of Harvard University (xix) shows that the spermagonia start "from an outgrowth between and not in the epidermal cells of the host." The pressure induced by the multiplication of fungous cells causes a breaking away and final absorption of the adjoining epidermal cells and the abnormal increase in size of those surrounding the forming spermagonium. A plate adds emphasis to the details of the process as described in the paper. B. D. H.

Flora of Cumberland, Md. (5 pages, no author given [Howard Shriver]; no date given [1892].)

An alphabetical list of several hundred species collected for the Cumberland High School.

Immigrant Plants in Los Angeles County, California. Anstruther Davidson (Erythea, i. 56–61; 98–104).

Jussiæa repens of Linnæus. F. von Mueller (Erythea, i. 61, 62).

Prof. Greene prints a letter from Baron von Mueller, calling attention to the fact that the true *Jussiæa repens*, L., occurs only in India, and that the North American plant so-called is probably *J. diffusa*, Forsk.

Lespedeza—The North American Species of. N. L. Britton. (Trans. N. Y. Acad. Sci. xii. 57–68; reprinted as Contrib. Herb. Col. Coll. No. 34.)

Twelve species are recognized and concisely described. Notes are given on distribution and on type specimens. Two new varieties are proposed.

Lichens of Lancaster County, Pennsylvania—Preliminary Enumeration of the. A. A. Heller (pp. 4, Lancaster, 1893).

A list of 78 species, with localities and habitats.

Loco—Some Observations upon. Dr. Mayo (Bull. Kans. Agric. Exp. Sta. No. 35).

The author concludes that the "Loco" disease is the result of malnutrition caused by the affected animals eating freely of *Astragalus mollissimus*, or *Oxytropis Lamberti*. The presence of any narcotic principle in these plants is doubted.

Mangrove-tree—The. (Garden and Forest, vi. 97).

With two illustrations of *Rhizophora Mangle*, one showing the tree rising from a mass of underbrush, the other showing the lower part of the trunk and the roots.

Mamillaria prismatica. (Bot. Mag. t. 7279).

Native of Mexico. A species of the group *Anhalonium*.

Metaspermæ of the Minnesota Valley. Conway MacMillan. (Rept. Geol. and Nat. Hist. Surv. Minn. Botanical Series, i. cloth, pp. 826, two maps; Minneapolis, Minn., dated Dec. 29, 1892).

In his preface the author expresses satisfaction at the action of the Botanical Club of the A. A. A. S., taken at the Rochester meeting of 1892, in its endeavor to establish nomenclature "upon some other than a personal basis," and states that the initial date, 1753, would have been adopted by him, for genera as well as species, in this work, had not most of it been in type when the Club's action was taken. In order to comply with the principle,

however, the following list is inserted for the convenience of those who may wish to note the necessary changes:

Mariscus, Hall. (1742). = *Cladium*, P. Br. (1756).
Cyperella, Cram. (1744). = *Juncodes*, Adans. (1763).
Ramium, Rumpf. (1747). = *Boehmeria*, Jacq. (1763).
Stellularia, Linn. (1748). = *Stellaria*, Linn. (1753).
Leuconymphæa, Ludw. (1737). = *Castalia*, Salisb. (1805).
Nymphæa, Ludw. (1737). = *Nymphæa*, Salisb. (1805).
Capnorchis, Ludw. (1737). = *Bikukulla*, Adans. (1763).
Cracca, Linn. (1747). = *Colonilla*, Adans. (1763).*
Ricinocarpus, Burm. (1737). = *Acalypha*, Linn. (1753).
Stellaria, Ludw. (1737). = *Callitriche*, Linn. (1753).
Lapula, Hall. (1745). = *Lappula*, Moench. (1794).
Leptostachya, Mitch. (1748). = *Phryma*, Linn. (1753).
Pentagonia, Sieg. (1737). = *Legouzia*, Dur. (1782).

The rule which excepts duplicate binomials, as *Phragmites Phragmites* (Linn.) from the law of priority, is also gracefully accepted, and wherever such binomials are found in the work the request is made that the second oldest specific name be used, although the author was not and is not now in sympathy with any such exception. The above binomial would thus become *Phragmites vulgaris* (Lam.).

An exceedingly terse and sharp enunciation of the author's views in regard to the question of nomenclature may be found under the heading "Citation of authors of genera and species" beginning on p. 11, which is worthy of attention from all who still believe in the "position of naming-plants-as-one-pleases." In tracing the history of the movement towards a stable system of nomenclature in America, Prof. Britton is given undue prominence. The argument was begun by Prof. Greene.

In its general classification the work is not only well abreast of the times, but far ahead of all our manuals and text books. All schemes of classification are necessarily evanescent or at least should be sufficiently elastic to permit of interpolation or amendment whenever newly discovered facts render it advisable or necessary, and, as the author says: "While, therefore, the constant shifting from one classification to another is exasperating to the

Cracca, L., appears in the "Species Plantarum" of 1753.

conservative student, it is nevertheless a necessary result of advancing information, and to refuse to consider the new systems which may be put forth in scientific fashion, is as unreasonable as it was in those days when the railway carriages were first brought into use for one to insist upon traveling by the old stage lines of an earlier mechanical era."

The author believes that "the eye should be cast forward instead of backward, that the future should receive consideration as well as the past." He also evinces no consideration for those who would leave all changes and innovations in nomenclature and classification to monographers. He believes that the public has a right to demand the best and most advanced ideas and convictions, even in local floras and catalogues, and in this we are in hearty accord, as it is mostly through these that a large number of lay botanists must receive such education, the ordinary text book being necessarily years behind the times.

The scheme of classification adopted in this work is based upon the most recent investigations in plant morphology.

Two main groups are recognized: A. PROTOPHYTA and B. METAPHYTA, based upon the absence or presence of sexuality. Exact limits between the two are necessarily impracticable, on account of the presence of transition forms, some of which seem to indicate a progressive development from the lower to the higher group—others which appear to be undergoing a retrograde metamorphosis. The Metaphyta are divided into I. GAMOPHYTA and II. SPOROPHYTA, dependent upon the development of the fertilized ovum. As examples of i. are given "the lower Zygophyta *and* Oophyta of Bessey, plants like the pond-scum (*Zygnema*) or the black-mould (*Rhizopus*, *Mucor*)." Division ii. would therefore comprise practically all plants with which we are familiar in the entire range of botany, except what we have been in the habit of calling the Protophyta and lower Thallophyta. In the Sporophyta three "alliances" are recognized:

(1). Thallophyta, which includes the seaweeds, fresh water algae, and the higher spore-fruit-producing fungi, such as mushrooms and puff balls.

(2). Archegoniatæ, which includes such forms as *Chara* and *Nitella*, the Hepaticae, the Musci, the Filices and their allies, Cycads, Conifers, etc.

(3). Metaspermæ, which includes all those plants formerly classed under Angiospermæ, or, in the words of the author, examples of the Metaspermæ may be selected from the great mass of plants which contain their seeds in a closed "ovary," better named "carpellum." These, then, are alone what have been considered by the author in the present work. Even our old and apparently firmly established friends the Mono- and Dicotyledones have been transferred to a more subordinate position than they once held, and we find the metaspermæ divided primarly into Chalazagameæ, consisting of the single genus *Casuarina*, and Porogameæ, which includes all the other Metaspermæ and in which the Mono- and Dicotyledons are at last permitted to figure as subdivisions. The former are not subject to any further subdivisions, but the latter are arranged, in accordance with the morphology of the perianth into Archichlamydaæ [Polypetalæ and Apetalæ], and Metachlamydeæ [Gamopetalæ]. The skeleton scheme of classification would thus appear:

A. Protophyta.

B. Metaphyta.

I. GAMOPHYTA.
II. SPOROPHYTA.

(1) THALLOPHYTA.
(2) ARCHEGONIATÆ.
(3) METASPERMÆ.

Metaspermæ.

(a) Chalazagameæ.
(b) Porogameæ.

1. Monocotyledones.
2. Dicotyledones.

Archichlamydeæ.
Metachlamydeæ.

Under this arrangement the list begins with Porogameæ (Monocotyledones), Family Typhaceæ, Genus *Typha*, Species *T. latifolia*, Linn. and terminates with Family Compositæ, Genus *Hieracium*, Species *H. Canadense*, Michx. The total number of families enumerated is 106, genera 407, and species and varieties 1,174.

The number of changes in long established names is necessarily considerable. Most of them have, however, already been adopted by other progressive botanists and have appeared in print

elsewhere. We note with some amusement that the author's rigid conscientiousness has caused him to take up Rafinesque's misprint name "*Scoria*," instead of "*Hicoria*," as he originally wrote it. The limitations of many genera and families are curtailed or extended, as the case may be, and several old genera are revived.

The bibliography and synonomy cover families, genera and species and evince an immense amount of careful and conscientious research, which will save many hours of labor to future workers in metaspermic botany for which they owe the author a heavy debt of gratitude. An innovation which will be welcomed by many is the citation, under the genus, of any fossil form which may have been identified. In this connection the geological horizon, locality and authority are given.

Following the list is a general description of the region, which includes its geographical location, physiography, distribution of forest and prairie, soil, climate and geological history. The palæobotanist will find in the chapter entitled, "Relationships of the Metaspermic Flora of the Minnesota Valley," much of interest and more or less food for thought. The old problems in regard to plant dissemination and distribution are again brought forward. "How did the present plant inhabitants enter the Minnesota Valley?" "What relation does this modern plant-population bear to the more ancient one which was overwhelmed by the glacial detritus, piled 250 feet thick over the old level of the country?" "Under what laws did the repopulation of the Valley progress?" "Along what routes did the incoming plants travel?" etc. The author begins this discussion by calling attention to the constant condition of strain or tension that exists between plants or groups of plants in the struggle for existence—in other words their "dynamic inter-relation." Such a condition he thinks should be recognized more fully in terminology and suggests that instead of speaking of a "northern" group of plants we should designate it as the "*south-bound*" group, and similarly a southern group might be called a "*north-bound*" group, as these plants, already established in the north or south, as the case may be, have probably reached their limits of extension to the north and south respectively, and whatever further extension is to be accomplished must be southward for the

northern plants and northward for the southern plants. A line or area of tension is thus formed, and if the world in general is considered, two main tension areas or zones will be apparent, one to the north and another to the south of the equator. In these zones of tension, where the competition between northern and southern forms is greatest, transitional floras are to be found. In the Minnesota valley the author notes the fact, which has received attention in other localities, that the southern or north-bound plants are largely endemic, or in other words American in type, while the northern or south-bound ones are generally less so, in other words foreign in type.

The division of the earth into natural vegetation regions has been attempted by several authorities, notably by Griesebach, Engler and Drude, all of whose regional classifications are given in full and discussed in so far as North America is concerned. The author's conclusions are that there is a greater homogeneity in the regions of the northern than in those of the southern hemisphere, the reasons being both geographical and geological. Geographically the facilities for migration and commingling are much more favorable in the northern than they are in the southern hemisphere, which latter consists of a series of isolated areas, whereas the former is practically a compact circle of land surrounding the pole, broken only by narrow bodies or arms of water. Geologically all the evidence is in favor of a closer relationship in recent times between Asia and North America than between the latter and Europe, and modern biological researches strongly emphasize the evidence. It has long been a well recognized fact that the plants of Greenland are remarkably distinct from those of Scandinavia, whereas the floras of Alaska and Northeastern Asia show but slight differences one to the other. The glaciation of the Ice Age also had a profound influence in modifying the distribution of the plants which previous to that time occupied the Arctic and sub-Arctic regions. In North America, where the mountain chains extend north and south, these plants could migrate or remain undisturbed to the south of the ice sheet; whereas in the old world, where the mountain systems are largely east and west, such plants would be cut off from any means of southward migration and would necessarily perish. "Decimation

of old world species would thus result in the conditions of difference as seen to-day between the old world and North America."

Returning again to the subject of "Pressures and Tensions," the conclusion is reached that, "Under the positive equatorial pressure opposed by the negative polar pressures, a segregation of metaspermic plants would take place," that is, the weaker or older types of plant life would gradually find themselves crowded out in the struggle for existence. Another result which the author emphasizes is that the weaker ones are forced to fight in the front, and as an example of this principle cites the line between forest and prairie in the Minnesota valley, where he says: "It is not the characteristic grass of the prairie that grows close up to the characteristic tree of the forest, but between the two there is a zone of plants not perfectly established in either forest or prairie. This transitional formation * * * is generally composed of species weaker than the characteristic plants of either formation."

Under the present climatological conditions the author sssumes, just why he does not make apparent, that the equatorial pressure is increasing, while that of the poles is decreasing, and that the line of tension is thus gradually progressing towards higher latitudes, although liable to local fluctuations due to physical and biological causes. In effect, this is putting into a somewhat different shape the observation of recent investigators, that there is an apparent gradual northward movement of our flora, which has been ascribed to a continuous amelioration of climate since Glacial times.

The influence of this pressure is also discussed in its relation to the specialization of the structure and habitat. Thus the least specialized plants, the aquatic, occupy the least specialized habitat, whilst amongst the most highly specialized, as for instance, the epiphytic orchids in the group of Monocotyledones, occupy the most highly specialized habitat.

Secondary longitudinal tensions, which are lines due to local geography, and minor tensions, due to the influence of topography in limited localities, are also discussed.

Under the heading "Outlines of Metaspermic History in the Northern Hemisphere" may be found a brief resume of what is known in regard to the development of the higher forms of vege-

table life since Jurassic times, with special reference to the Cretaceous or Tertiary floras which have been identified in the region under discussion. With the advent of the Ice Age of course all these were destroyed except such as could migrate or exist southward. The author concludes that of all these "none showed greater capacity for variation and improvement than the ancestral forms of the modern dominant family of the Compositæ," whose seeds could fly before the prevailing north winds or attach themselves to the fur of migrating animals, and would be assisted on their return by similar influences. Necessarily the changes in soil, climate and topography would so alter the conditions that a majority of the species could not exist over the region once occupied by them. Others perished by the way, and most of them were modified in one direction or another in their Tertiary southward migration and their subsequent northward migration in recent times.

At the present day the same or similar forces are at work changing or modifying the distribution and structure of plants, but a new element, the influence of man, is now at work. Thus in the Minnesota valley he is responsible, according to the author, for the introduction and establishment of 130 alien forms and the extermination of many native ones from localities where they were once abundant.

Under the statistical discussion of the facts, which occupies about 150 pages, at the close of the volume, may be found a great many interesting and often significant results and comparisons, which want of space does not permit us to review.

A complete family, generic and specific index, with synonyms in italics, terminates the work. It could hardly be rendered more exhaustive, and may be taken as a type of what such books should be. We trust that the author has in mind a work which shall cover the Archægoniatæ and that it will be carried to completion in the same thorough, conscientious and progressive spirit.

A. H.

Monarda fistulosa—Notes on, and the Phenomenon of Fertilization in the Flowers of. Thomas Meehan, Ida A. Keller (Proc. Acad. Nat. Sci. Phila., 1892, 449–454; one plate; reprinted).

Monterey Bay—A Month on the Shores of. Marshall A. Howe (Erythea, i. 63–68).

A contribution to the local algology of the California coast with a list of about 105 species collected.

Musci Americæ Septentrionalis, ex operibus novissimis recensiti et Methodice dispositi. Renauld et Cardot (Rev. Bryol. xx. 1–32, 1893).

This second part completes the check-list of North American mosses, with 1370 numbers. The resume at the end states that 675 are endemic; 297 occur in Europe and Siberia; 348 in Europe alone, and 12 in Siberia alone; 91 in the West Indies, Mexico, or South America, and 76 in Japan. We are sorry for the collector who attempts to exchange or complete his herbarium with this as a basis. We note a certain carelessness of citation, for which Macoun's Catalogue is responsible, as in the case of *H. Flemmingii*, Austin (not L. & J.). We had supposed *H. Bergenense*, Aust. was a synonymn of *H. hygrophilum* (Jur.) Sch., but we find both cited as 1230 and 1253. Nos. 1189–1191 are credited to L. & J., not to Austin as they should be, *H. Oakesii*, to Schimper, not to Sullivant, and *H. Pyrenaicum*, which antedates it, according to Lindberg, is ignored.

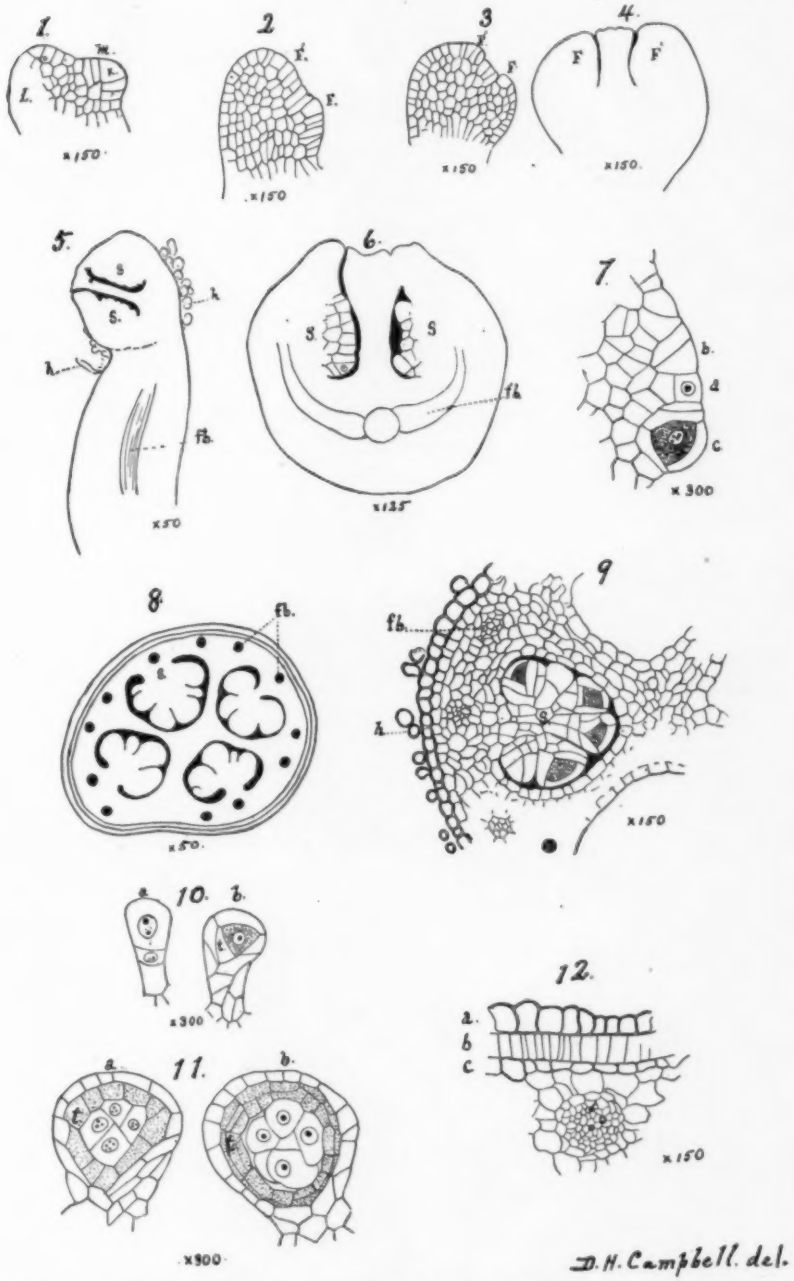
In fact the whole catalogue shows that we are in need of a new American check-list, on the basis of the Rochester Code, in which some effort shall be made to sift the good from the bad, and the typography shall be less straining to the eyes than the one just printed. We shall hope to see it issued by American authors. E. G. B.

Opening of the Buds of some Woody Plants.—A. S. Hitchcock (Trans. Acad. Sci. St. Louis, vi. 133–141; four plates; reprinted).

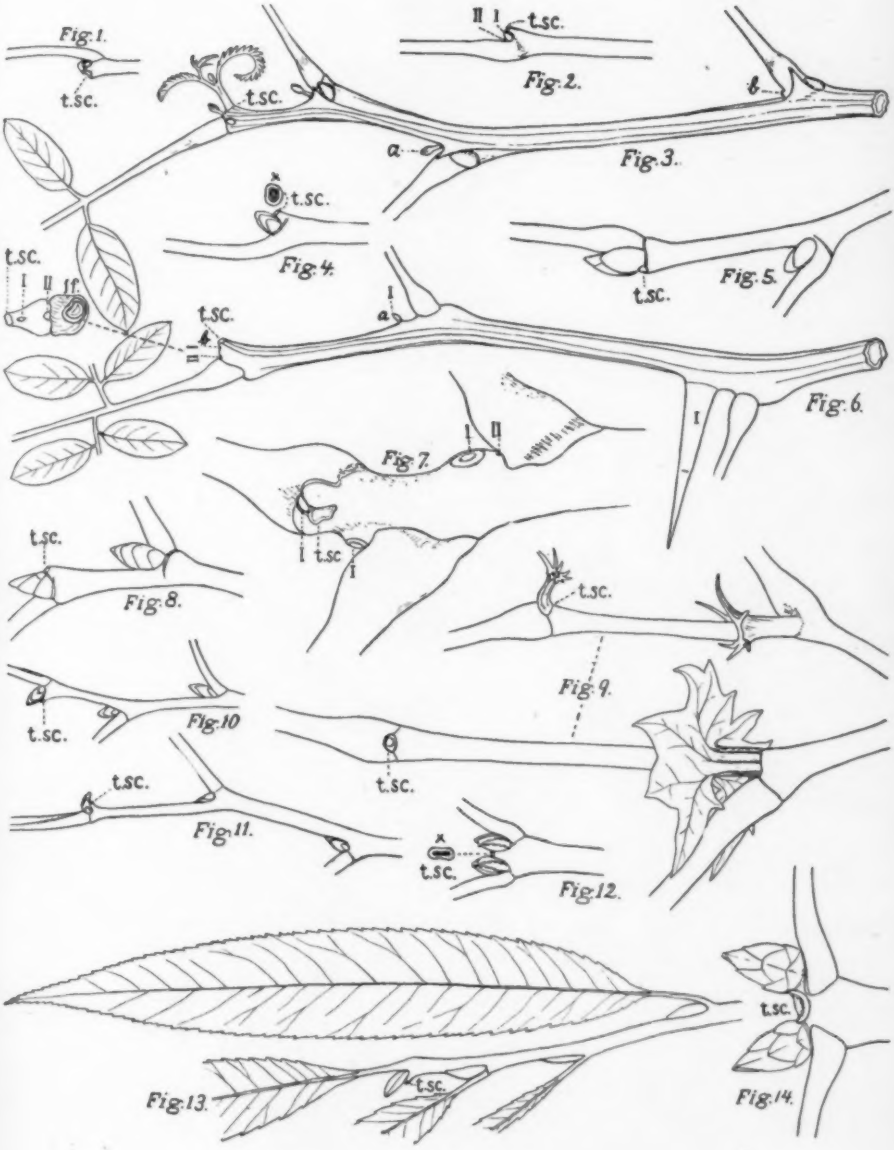
Pellæa gracilis (Meehan's Monthly, iii. 33, plate 3).

Pilocereus Melocactus.—K. Schumann (Monatsb. Kakteenk. iii. 20–25).

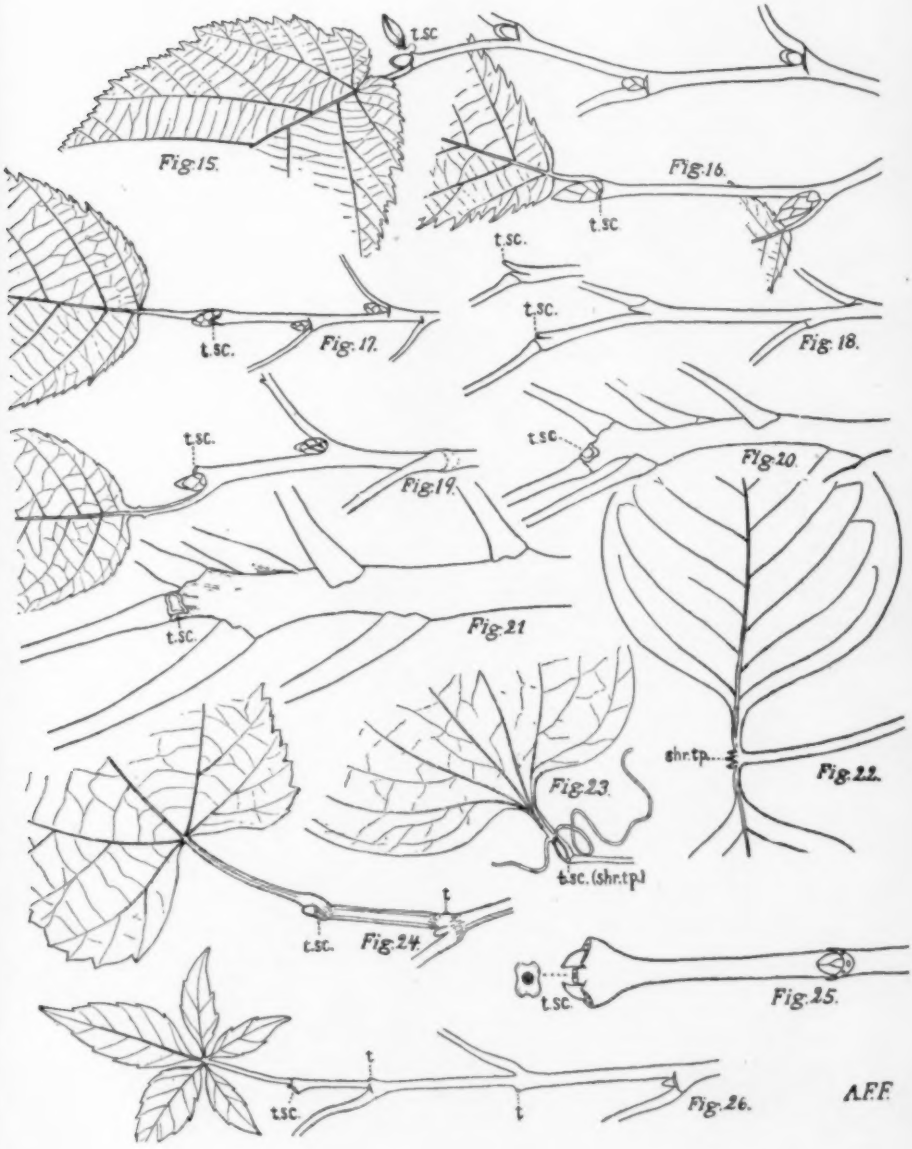
Native of Brazil.



DEVELOPMENT OF THE SPOROCARP OF PILULARIA AMERICANA, A. BR.—DOUGLAS H. CAMPBELL.



ON THE CASTING-OFF OF THE TIPS OF TWIGS.—A. F. FOERSTE.



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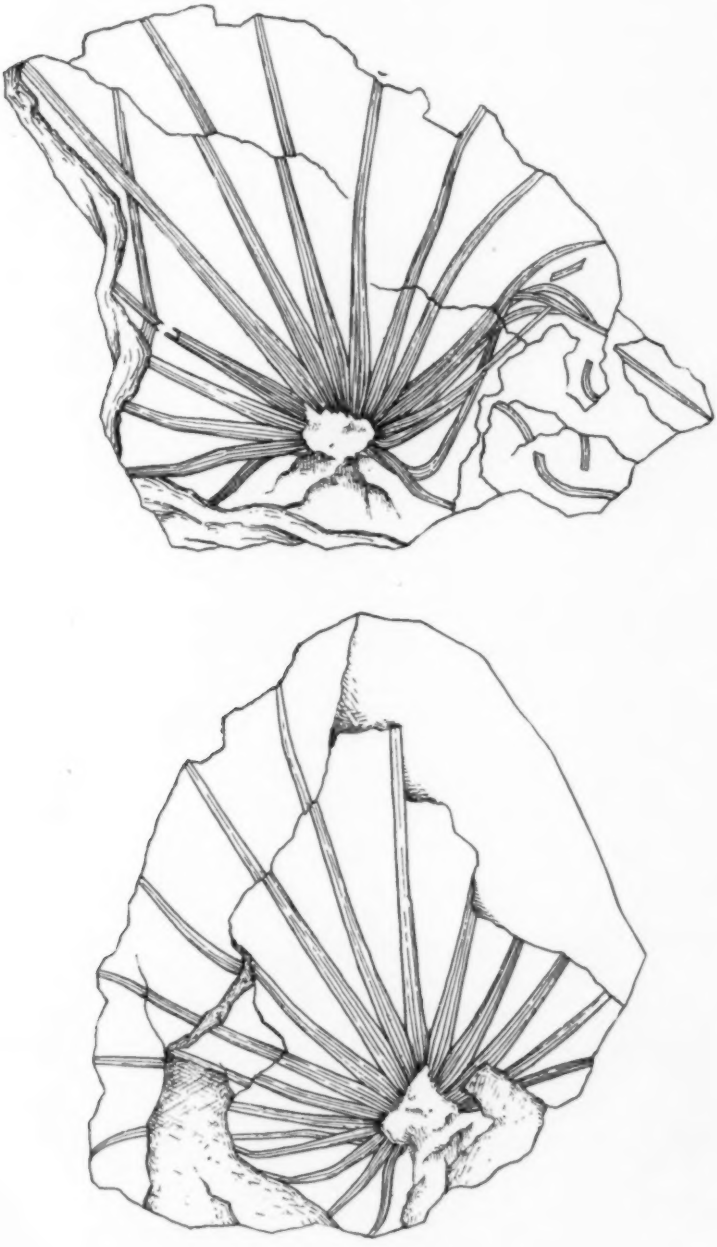

SERENOPSIS KEMPII, HOLLICK.